ABG analysis & Acid-Base Disorders

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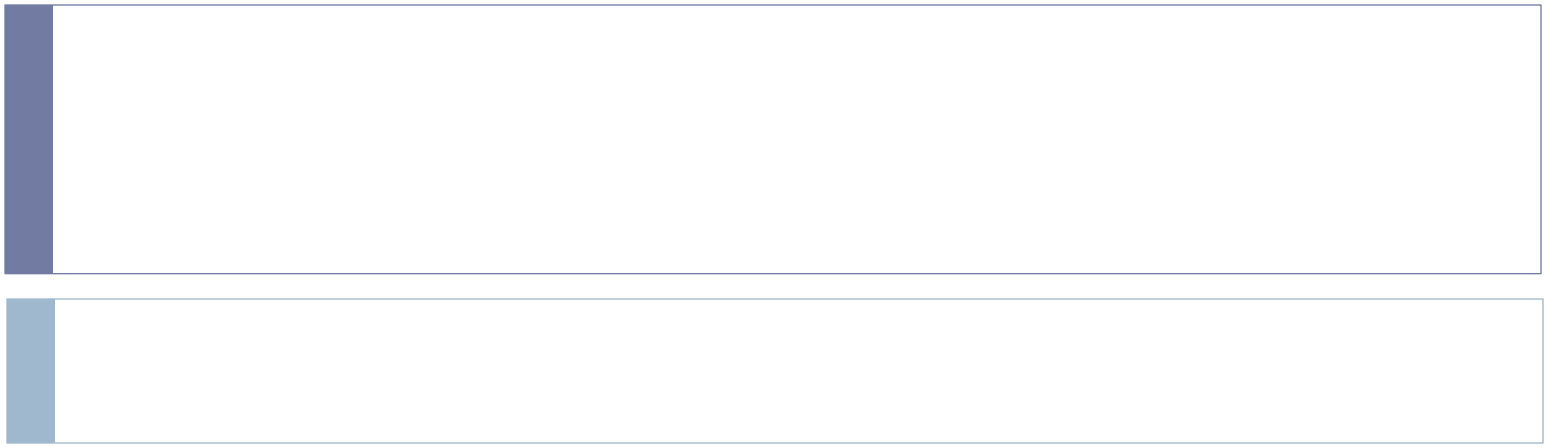

Outline

1. **Discuss simple steps in analyzing ABGs**
2. **Calculate the anion gap**
3. **Calculate the delta gap**
4. **Differentials for specific acid-base disorders**

Steps for ABG analysis

1. **What is the pH? Acidemic or Alkalemic?**
2. **What is the primary disorder present?**
3. **Is there appropriate compensation?**
4. **Is the compensation acute or chronic?**
5. **Is there an anion gap?**
6. **If there is a AG, what is the delta gap?**
7. **What is the differential for the clinical processes?**

Normal Values

Variable	Primary Disorder	Normal Range	Primary Disorder
pH	**Acidemia**	**<- 7.35 - 7.45 ->**	**Alkalemia**
pCO2	**Respiratory alkalosis**	**<- 35-45 ->**	**Respiratory Acidosis**
Bicarbonate	**Metabolic acidosis**	**<- 22-26 ->**	**Metabolic alkalosis**

Step 1:

- **Look at the pH: is the blood <u>acidemic</u> or <u>alkalemic</u>?**

Step 2: What is the primary disorder?

What disorder is present?	pH	pCO2 or HCO3
Respiratory Acidosis	pH low	pCO2 high
Metabolic Acidosis	pH low	HCO3 low
Respiratory Alkalosis	pH high	pCO2 low
Metabolic Alkalosis	pH high	HCO3 high

Step 3: Is there appropriate compensation?

- **Respiratory Acidosis**
  - **Acute: for every 10 increase in pCO2 -> HCO3 increases by 1**
  - **Also know for every acute increase of 10 in pCO2 there is a decrease of 0.08 in pH MEMORIZE**
  - **Chronic: for every 10 increase in pCO2 -> HCO3 increases by 4**
  - **Also know for every chronic increase of 10 in pCO2 there is a decrease of 0.03 in pH**
- **Respiratory Alkalosis**
  - **Acute: for every 10 decrease in pCO2 -> HCO3 decreases by 2**
  - **Chronic: for every 10 decrease in pCO2 -> HCO3 decreases by 5**

Step 3: Is there appropriate compensation?

- **Metabolic Acidosis**
  - **Winter's formula: $pCO_2 = 1.5[HCO_3] + 8 \pm 2$ MEMORIZE**
  - **If serum pCO_2 > expected pCO_2 -> additional respiratory acidosis**
- **Metabolic Alkalosis**
  - **For every 10 increase in HCO_3 -> pCO_2 increases by 6**

Step 4: Calculate the anion gap

- **AG = Na – Cl – HCO3 (normal 12 ± 2)**
- **AG corrected = AG + 2.5[4 – albumin]**
- **If AG > 20, a metabolic acidosis is always present**

Differential for Anion Gap Metabolic Acidosis - MUDPILERS
Methanol
Uremia
Diabetic ketoacidosis, starvation ketoacidosis, EtOH ketoacidosis
Paraldehyde
INH, iron toxicity
Lactic acidosis
Ethylene glycol
Rhabdomyolysis
Salicylates

Step 5: Calculate the delta gap

- **Only need to calculate delta gap (excess anion gap) when there is an anion gap present to determine additional hidden metabolic disorders (nongap metabolic acidosis or metabolic alkalosis)**
- **Delta gap = AG – 12 + HCO3 (normal 23-30)**
- **If delta gap > 30 -> additional metabolic alkalosis**
- **If delta gap < 23 -> additional nongap metabolic acidosis**
- **If delta gap 23 – 30 -> no additional metabolic disorders**

Nongap metabolic acidosis

For nongap metabolic acidosis, calculate the urine anion gap

$$U_{AG} = U_{NA} + U_{K} - U_{CL}$$

If UAG>0: renal problem
If UAG<0: nonrenal problem (most commonly GI)

In working kidneys: HCl + NH3 ↔ NH4CL, urine chloride increases, UAG <0.

Causes of nongap metabolic acidosis - DURHAM
Diarrhea, ileostomy, colostomy, enteric fistulas
Ureteral diversions or pancreatic fistulas
RTA type I or IV, early renal failure
Hyperailmentation, hydrochloric acid administration
Acetazolamide, Addison's
Miscellaneous – post-hypocapnia, toulene, sevelamer, cholestyramine ingestion

Metabolic alkalosis

- **Calculate the urinary chloride to differentiate saline responsive vs saline resistant**
- **Must be off diuretics in order to interpret urine chloride**

Saline responsive U_{Cl}<10	Saline-resistant U_{Cl} >10
Vomiting	**If hypertensive: Cushings, Conn's, RAS, renal failure with alkali administartion**
NG suction	**If not hypertensive: severe hypokalemia, hypomagnesemia, Bartter's, Gittelman's, licorice ingestion**
Over-diuresis	**Exogenous corticosteroid administration**
Post-hypercapnia	

Causes of Respiratory Alkalosis
Anxiety, pain, fever
Hypoxia, CHF
Lung disease with or without hypoxia – pulmonary embolus, reactive airway, pneumonia
CNS diseases
Drug use – salicylates, catecholamines, progesterone
Pregnancy
Sepsis, hypotension
Hepatic encephalopathy, liver failure
Mechanical ventilation
Hypothyroidism
High altitude

Causes of respiratory acidosis
CNS depression – sedatives, narcotics, CVA
Neuromuscular disorders – acute or chronic
Acute airway obstruction – foreign body, tumor, reactive airway
Severe pneumonia, pulmonary edema, pleural effusion
Chest cavity problems – hemothorax, pneumothorax, flail chest
Chronic lung disease – obstructive or restrictive
Central hypoventilation, OSA

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